Author Responses

Re-discovering Robert E. Horton's Lake Evaporation Formulae: New Directions for Evaporation Physics

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Dear Ms. Jansen and Dr. Teuling,

Thank you for your valuable review comments. Prof. Singh and I reviewed your comments, and we provide our point-by-point response below.

For convenience of reading, we have indented your comments, reduced font size, italicized, and changed color to blue.

Thanks and best wishes,

Solomon Vimal and Vijay P. Singh

Responses to Reviewer 2

> *The manuscript by Vimal and Singh brings back to our attention the century old Horton's lake evaporation formula. The authors give a thorough historical overview on how the formula was developed and how it relates to other evaporation methods of varying complexity. The authors show us that Horton's formula outperforms the other methods. I have appreciated reading the manuscript that has been written in a story-telling form including quotes of the original papers of Horton. This provides the reader a good overview and sense on how the authors have reconstructed how Horton's formula was developed and subsequently fell into oblivion. The authors managed to re-awaken the use of it by applying it on data from a subarctic Canadian catchment and found that the use of the variable vapor pressure deficit (VVPD) term introduced by Horton is of added value compared to the use of only VPD which is frequently used in other evaporation methods. In short, I have read the manuscript with great interest and I think it fits the special issue History of hydrology. My suggestion is to publish the manuscript with very minor revisions for which I provide feedback in my comments below.*

SV and VS: We are pleased to receive this comment, and we thank Ms. Jansen and Dr. Teuling for their prompt review.

> ***General comments***
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> *- Please, provide units when explaining the variables of equations for clarity. In some cases it is given (e.g. p.12 L.358), but in most not.*

SV and VS: Thank you for pointing this out, we provided units in the first instance when any new term appears, but not in all subsequent instances. However, for the sake of clarity, we can add units in each step in the supplementary section where we plan to add a one page summary of the steps to use Horton's equation for practitioners (for pan and lake applications), where we can include metric and US units for comprehensiveness and clarity. We decided to include this after a comment we received from Reviewer 1 (see our responses to Reviewer 1)

> *- The order of the tables as they are mentioned in the text is the other way around of the appearance of the tables itself.*

SV and VS: We thank you for pointing this out, we have noted this, and will update the manuscript.

> ***Specific comments***
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> *- Is there a specific reason why the authors are using θ for temperature, instead of the commonly used T? To my knowledge θ is more commonly used to indicate potential temperature.*

SV and VS: We thank you for this question. We use θ because it is the notation that Horton used. Our goal in this paper was to encourage readers to revisit Horton's original work so we feel that adopting his notations would aid the reader who wishes to revisit Horton's paper(s). To disambiguate that θ is not potential temperature, we will explicitly say so in the first instance when it appears. Thanks for pointing this out!

> *- p.11 L.315 and L.325; w.r.t. – don't write as abbreviation*

SV and VS: We thank you for noticing this.

> *- p.14 L.422-425; in more recent past, there are many other studies that have found Dalton's method to work well. Especially in the oceanographic community it is widely used. The authors could refer to that as well for a bit of nuance.*

SV and VS: We thank you for bringing this to our attention. It might be a good idea to make this note as a passing remark. We can look for recent literature from the Oceanographic community, but if you happen to have any key reference or authors that come to mind, especially any that demonstrate that Dalton's method works particularly better than other methods, we would appreciate it if you can send the reference to the corresponding author (solomon.vimal@gmial.com).

> *- P.16 L.490; the reference of Vimal and Mikuszeit, 2021, is not included in the reference list of the manuscript.*

SV and VS: We thank you for this comment, please see line 990.

> *- P.18 L.534; humidity and temperature gradients is probably referring to horizontal gradients.*

SV and VS: We thank you for this comment. Yes, and we have a few thoughts to share here (perhaps this can go unsaid in the manuscript): as we understand it, the humidity gradient can be both horizontal (due to dry wind moving moisture) and vertical (as vapor blanket thickness can vary substantially: the maximum approaches infinity for fully saturated air over a large lake) and temperature gradient referred here is horizontal (perhaps caused due to vertical mixing at various parts of the lake that have variable depths (bathymetry), shading effects from cloud, mountain, etc.).

> *- P.18 L.533/534; do the authors have a reference that underpins the statement that evaporation rates are constant over large lakes?*

SV and VS: Thank you for this question. This was not meant in any strict sense, and our thinking was as follows, and we hope this addresses your concerns (if any). We will clarify this thinking succinctly in the line you quoted: over a pan, the role of vapor blanket is important, but the contribution of variable evaporation in the fringes of the lakes is negligible (not to say vapor blanket height variation doesn't exist, but that variable evaporation rates can be ignored as the area, fringes of lakes, involved is small enough). If this sentence is read outside this paragraph, it has little meaning as over large lakes we can expect vertical mixing of lakes which changes the evaporation rates with or without vapor blankets, but in summers and in all cases of more than laminar (gentle, convective moisture transporting) surface wind (which is most of the time), and more generally, over lakes that are warmer than 4 degrees (if other factors that affect density and incoming radiation aren't significant), they would have more or less the same temperature because of how wind induced turbulent mixing happens rapidly on the surface and equalizes the temperature. But this equalization can be offset by vertical mixing in cold lakes.

> *- P.18 L.534-539; First, the authors state that horizontal variability of the thickness of the vapor blanket is negligible, while the next paragraph is*

dedicated to the importance of horizontal variation and it is mentioned that this is the main theoretical breakthrough of Horton. Please, make this transition more clear or explain better.

SV and VS: We thank you for this comment, we will introduce the following explanation to clarify this in the paper: “The reason for it being an important breakthrough is that it resolves and explains why pans and large lakes have different evaporation rates. It shows why in large lakes vapor blanket can be ignored, and why it would be a big mistake to ignore it from pans. This has large implications for the evaporation paradox.”

- P.20 L.583; typo: Vercauteeren --> Vercauteren

SV and VS: Thank you for pointing this out!

- P.20 L.584; do the authors mean ‘were not explored’ instead of ‘were not unexplored’?

SV and VS: Thank you for pointing this out! We will correct it.

SV and VS: Again, we thank both reviewers and the editor for the careful review and editorial work that improved the quality of this manuscript.

With best wishes,

Solomon Vimal and Vijay P. Singh